DOCUMENT RESUME

ED 257 677 SE 045 774

AUTHOR Okey, James R.
TITLE The Effectiveness of Computer-Based Education: A Review.
PUB DATE 85
NOTE 13p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (58th, French Lick Springs, IN, April 15-18, 1985). For related papers, see SE 045 491 and SE 045 773.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150) -- Information Analyses (070)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; *Computer Assisted Instruction; *Computer Oriented Programs; Conventional Instruction; *Educational Research; *Educational Trends; Elementary Secondary Education; Learning; *Microcomputers
IDENTIFIERS *Computer Uses in Education

ABSTRACT

Research reports issued during the last decade and a half on the effectiveness of computer-based education (CBE) are examined. Surveys of research on CBE over this time period are considered rather than individual studies. Thus, this report represents a synthesis of a number of review articles which provide snapshots across two decades of the kind of CBE work that was being done and the impact that CBE was having on learning. Specific questions addressed are: (1) How effective is CBE in promoting learning? (2) Under what conditions does CBE have differential effects? (3) Are some forms of CBE more effective than others? (4) What trends in the effectiveness of CBE are evident over the years? Among the answers are these: CBE is effective in promoting learning. Most studies show CBE to be better than conventional instruction. Young children seem to be affected more powerfully than older learners and low ability more strongly than high ability. Computer-assisted instruction shows a larger impact on achievement than computer-managed instruction. Supplementing instruction with computers may be more effective than providing a total computer environment. Microcomputers are now becoming common and instruction with them will become the dominant form of the future. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED257677

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

THE EFFECTIVENESS OF COMPUTER-BASED EDUCATION: A REVIEW

James R. Okey

Department of Science Education
University of Georgia
Athens, GA 30602

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Michael L. Waugh
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Paper presented at the Annual Meeting of the
National Association for Reasearch in Science Teaching

French Lick Springs, Indiana
April, 1985

SE 045 774

The Effectiveness of Computer-Based Education: A Review

James R. Okey
Department of Science Education
University of Georgia
Athens, GA 30602

Computers have been used in instruction for more than 20 years. During this time the instructional role the computer plays has varied widely. In some cases, a total course of instruction may be presented by the computer. In others, modest additions or supplements to instruction are provided in the form of brief computer simulations, drills, or tutorials. Computers have also been indirectly involved in instruction in behind-the-scences roles by serving as test generators, record keepers, or word processors. In these cases, learners have no direct interaction with the computer but they or their instructors use materials the computer generates. Recent development in technology have widened the range of uses to interactive videotape and videodisc instruction in which computers serve as controlling devices for integrated computer displays, still or motion pictures, and sound.

Like other innovations in education (film, overhead projectors, television, programmed instruction), advocates have promised major effects in what, how, and how well students will learn when computers are installed and used in schools. The purpose of this paper is to examine research reports issued during the last decade and a half concerning the effectiveness of computer-based education (CBE). To accomplish this, surveys of research on CBE will be examined over this time period rather than individual studies of CBE effectiveness. Thus, this report is a synthesis of a number of review articles which provide snapshots across two decades of the kind of CBE work that was being done and the impact that CBE was having on learning. The major questions to be addressed in this paper are:

1. How effective is computer-based education in promoting learning?

2. Under what conditions does computer-based education have differential effects?

3. Are some forms of computer-based education more effective than others?

4. What trends in the effectiveness of CBE are evident over the years?

BEST COPY AVAILABLE

BEST COPY AVAILABLE

Evolution of CBE

Early studies of computers in education were done exclusively on mainframe computers (the only ones that existed at that time). Their size, cost, and maintenance limited their availability. Further, the focus in these early days of instructional computing was necessarily on development and feasibility. Instruction on the computers was principally tutorial or drill and practice. Some of these computers serviced visual displays on terminals but others provided only printed interactions. Graphic displays were possible but limited. Each mainframe computer could handle a limited number of student stations (e.g., the IBM 1500 system serviced about two dozen terminals in a time sharing mode). There were only a few computers available for or dedicated to instruction and only a small number of students that each of these could service. This combination of circumstances meant that CBE was a phenomenon suitable for research, development, and evaluation but not one that was currently affecting learning in a significant way.

Computer terminals were ultimately freed from their short tether to a mainframe by operation over telephone lines but it was not until 1977 that the introduction of microcomputers made possible computing in a truly distributed fashion. Limited phone ports and heavy user demands in time sharing systems were no longer problems when the only connection to the outside would for the microcomputer was to a source of electrical power. Further, the costs to purchase and operate microcomputers and their size and portability led to computer availability in virtually every school or college. The estimates in 1983 were that there were more than 340,000 microcomputers available for instruction in U.S. schools (Ingersoll and Smith, 1984) -- an increase of 185% over the previous year. The accelerated levels of purchase since that report have greatly expanded microcomputer access for students at all levels of education.

Recent developments in CBE have continued the use of drill/practice and tutorial instruction and increased the emphasis on computer simulations, problem solving, and logical thinking exercises (Tinker, 1983). Diagnostic testing, providing instructional prescriptions, collecting laboratory data, using data bases, and solving problems algorithmically are some of the newer computer applications in instruction.

Research on CBE

Despite the need to concentrate heavily on development, installation, and implementation in the early days of instructional computing, the question of effectiveness has always been present. Is the new teaching medium effective in

BEST COPY AVAILABLE

bringing learners to some designated level of achievement and how do computers compare to conventional instruction in accomplishing instructional goals? These fundamental questions have altered but slightly over two decades of instructional computing research. The answers to them have increased in importance in recent years with the introduction of numerous small computers in schools, business and industrial training settings, and in government teaching and training. When few computers existed, questions concerning the effectiveness of CBE were primarily of academic interest. Now that they are numerous, educational administrators and policy makers need to be concerned.

Four factors have usually been the focus of CBE studies -- achievement, attitudes, time to learn, and costs. A typical CBE effectiveness study will contrast the achievement, attitudes, and time to learn of a group of students using computers with a group receiving conventional instruction. Cost effectiveness studies are more rare but attempt to assess human, machine, and facilities costs in conventional and CBE environments. Some attempt to amortize computer equipment costs over time is usually included.

Results from CBE Studies

Table 1 presents a chronology of CBE reviews published over a 14 year period. The earliest review are exclusively of mainframe computer use. The later reviews pick up studies in which microcomputers are the instructional medium. The studies represented in these reviews are neither mutually exclusive nor collectively exhaustive. Some of the reviews necessarily found the same studies as they examined the literature and some CBE studies surely must have failed to find their way into a reviewers purview. What the reviews represent are glimpses across time, in specific subject areas, and at certain grade levels of the effectiveness of CBE.

Vinsonhaler and Bass (1972) presented one of the first reviews of CBE studies. They looked at results from 10 drill and practice studies (some studies were conducted at various locations so results are presented for 34 different sites) in elementary school mathematics and language arts. In all cases, CBE was used as a supplement to existing conventional instruction. Reports of 5 language arts studies revealed a mean difference of .3 grade equivalent units favoring CBE students. For 29 reports of mathematics learning, a mean difference of almost .4 grade equivalent units again favored use of CBE. Only 4 studies of the 34 examined showed nearly neutral or negative results and only one of these was of any size. Vinsonhaler and Bass conclude that "there appears to be little reason to doubt that CAI plus traditional classroom instruction is usually more effective than traditional instruction alone in developing skills."

BEST COPY AVAILABLE

Thomas (1979) provides a narrative review of several dozen CBE studies which examine achievement, attitude, time, retention, and cost effects. He concluded that "achievement gains over other more traditional methods are the norm", "retention is equal to that obtained in traditional instruction", "the technology fosters generally favorable attitudes", "CAI students gain mastery status in a shortened period of time", and, "CAI cost appears to be approaching that of conventional instruction."

Edwards, Norton, Taylor, Van Dusseldorp, and Weiss (1974) attempted to "critically examine the effectiveness of CAI as an instructional tool." Following a review of 33 CBE studies, they concluded that "increased achievement results from the use of CAI", "drill and practice is the most consistently effective mode", CAI is no more effective than other nontraditional methods of instruction such as programmed instruction or language labs, "learning time can be compressed through CAI", "CAI seems to be more effective for low ability than for middle or upper ability students", "boys tend to gain more from CAI than girls", and that, "student's and teacher's attitudes toward CAI have found that both groups like CAI."

In the first reported meta analysis of CBE studies, Kulik, Kulik, and Cohen (1980) examined findings in college level studies. Their results of 54 studies that reported examination performance of college students found 37 to favor use of CBE and 17 to favor conventional instruction. Of 14 statistically significant differences in the 54 studies, 13 favored CBE. A mean effect size of .25 was calculated for the 54 studies -- a small but practically significant effect. Student attitudes in a CBE environment were also assessed in this review. A total of 11 studies showed mean effects of .24 and .18, respectively, for attitudes toward CBE and the subject matter. Eleven of the studies they examined provided evidence on instructional time. About two-thirds as much time was spent in the CBE classes compared to conventional instruction.

Burns and Bozeman (1981) reviewed studies of CBE in mathematics in another of the early attempts to use meta analysis to integrate findings from many disparate sources. The 40 studies they examined were done either with elementary or secondary students in a drill/practice or tutorial mode. They reported a mean effect size of .34 for drill and practice studies and .44 for tutorial studies. They concluded that, "the analysis and synthesis of many studies do point to a significant enhancement of learning in instructional environments supplemented by CAI."

As a part of a larger meta analysis of instructional systems (e.g., mastery learning, PSI, individualized

BEST COPY AVAILABL

instruction), Willett, Yamashita, and Anderson (1983) located 14 effects (not studies) in which CBE impact could be analyzed. An overall mean effect size of .13 was found (.01 for 5 CAI measures, .05 for 8 CMI measures, and 1.45 in one study of computer based laboratory simulations).

Wise and Okey (1983) reviewed science and mathematics achievement in studies which used microcomputers. Only 12 studies were located, the earliest being reported in 1980. An average effect size of .82 was found. This would correspond to a shift in achievement of 29 percentile units.

In their review of the effects of CBE on secondary students, Kulik, Bangert, and Williams (1983) found an average effect size of .32 in 48 studies. Effect sizes ranged from -.5 to 1.5 standard deviation units. Low ability students seemed to be influenced more than high ability students by CBE (.45 for low, .13 for high). More recent studies had substantially larger effect sizes than those reviewed from the 1960's. Retention and attitudes were also examined in this review but no differences of note were reported in the few studies that addressed these outcomes.

Kulik, Kulik, and Bangert-Drowns (1985) analyze results from 32 studies of CBE in elementary school classrooms. Substantial differences in effect sizes were found for computer-assisted instruction (.47 in 28 studies) but not for computer managed instruction (.07 in 4 studies). In the 28 CAI studies, 23 of 28 statistically favored CBE and in no case did conventional students outscore CAI students. The mean effect size of .47 is equivalent to 18 percentile units difference between treatment and contrast groups or 5 months if grade equivalent units are used.

Conclusions and Implications

To return to the four major questions posed at the beginning of this paper, the answers appear to be --

1. CBE is effective in promoting learning. The effects are consistent across dozens of studies. Most studies show CBE to be better than conventional instruction. Rarely is conventional instruction superior.

2. Positive effects of CBE have been found in a variety of curriculum areas although studies in math and science predominate. Young children seem to be affected more powerfully than older learners and low ability more strongly than high ability.

3. Computer-assisted instruction shows a larger impact on achievement than computer-managed instruction. The effectiveness of drill and practice CBE is

 BEST COPY

prominent in the literature but more studies have been done in this area than in any other. Supplementing instruction with computers may be more effective than providing a total computer environment.

4. The trends in CBE are to extend computer use to a wider range of outcomes -- simulations and problem solving are now studied as well as drill/practice and tutorial modes. Microcomputers are now becoming common and instruction with them will become the dominant form of the future.

No reasonable arguments can be made for failing to use CBE as a supplement to regular instruction in science classrooms. The effectiveness of CBE has been extensively documented over more than 20 years. The immediate results of using CBE in classrooms should be to boost achievement and to save time. In addition, other likely events that will occur are to widen the range of outcomes pursued in the science classrooms. The newer software which presents computer simulations, provides problem solving opportunities, and supplies tools for data collection and analysis promises to expand the range of topics typically pursued in science programs.

School decisions are based on policies established by boards and administrators. Policies may be established for a variety of reasons but should, to the degree possible, be based on information and data (see Figure 1). Policies along with necessary products and procedures influence practices.

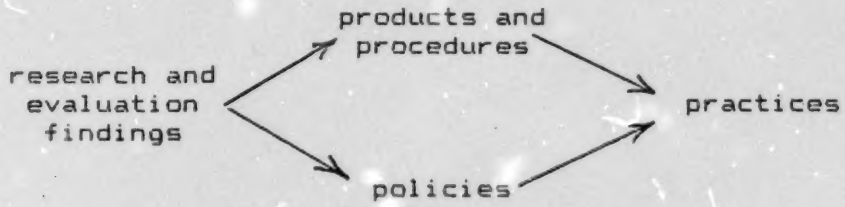

Figure 1. The relationship among research findings, policies, and practices.

There is no doubt that research and evaluation findings strongly support the use of computers in instruction. Products and procedures for CBE are numerous and growing. Policies are being established in schools for how, where, and by whom computers will be used but these tend to not connect computing with subject matter instruction. Instead, computer literacy courses abound. While such courses surely have

BEST COPY

value, the promise of the computer is that it will play an integral role in classroom instruction, used routinely by students and teachers in the teaching and learning of science. That practice is warranted by the research but is not commonly found in schools.

References

Atkinson, M. (1984) Computer-assisted instruction: Current state of the art. Computers in the Schools, 1(1), 91-99.

Bangert-Drowns, R.; Kulik, J.; & Kulik, C. (1984) The coming of age of educational technology: Meta analyses of outcome studies of computer-based instruction. Proceedings of the 25th International ADCIS Conference, Columbus, Ohio, 168-171.

Bracey, G. (1982) Computers in education: What the research shows. Electronic Learning, November-December, 51-54.

Burns, P. & Bozeman, W. (1981) Computer-assested instruction and mathematics achievement: Is there a relationship? Educational Technology, 21(10), 32-39.

Edwards, J.; Norton, S.; Taylor, S.; Van Dusseldorp, R.; & Weiss, M. (1974) Is CAI effective? Association for Educational Data Systems Journal, 7, 122-126.

Fisher, G. (1983) Where CAI is effective -- A summary of the research. Electronic Learning, 3(3), 82ff.

Fisher, G. (1984) The social effects of computers in education. Electronic Learning, 3(6), 26ff.

Forman, D. (1982) Search of the literature. The Computing Teacher, 9(5), 37-51.

Hartley, J. (1976) Computer assisted learning in the sciences: Some progress and some prospects. Studies in Science Education, 3, 69-96.

Hartley, S. (1978) Meta-analysis of the effects of individually paced instruction in mathematics. Dissertation Abstracts International, 38(7-A), 4003. (University Microfilms No. 77-29,926)

Ingersoll, G. & Smith, C. (1984) Reported availability of microcomputers in American schools: Year 2. Proceedings of the 25th International ADCIS Conference, Columbus, Ohio, 230.

BEST COPY

Jamison, D.; Suppes, P.; & Wells, S. (1974) The effectiveness of alternative instructional media: A survey. Review of Educational Research, 44, 1-61.

Kearsley, G.; Hunter, B.; & Seidel, J. (1983) Two decades of computer-based instruction projects: What have we learned? Technological Horizons in Education, 10(3), 90-94 and 10(4), 88-96.

Kulik, J. & Bangert-Drowns, R. (1983) Effectiveness of technology in precollege mathematics and science teaching. Journal of Educational Technology Systems, 12(2), 137-158.

Kulik, J.; Bangert, R.; & Williams, G. (1983) Effect of computer-based teaching on secondary school students. Journal of Educational Psychology, 75(1), 19-26.

Kulik, J.; Kulik, C.; & Bangert-Drowns, R. (1985) Effectiveness of computer-based education in elementary schools. Ann Arbor, MI: University of Michigan, 31p.

Kulik, J.; Kulik, C.; & Cohen, P. (1980) Effectiveness of computer-based college teaching: A meta analysis of findings. Review of Educational Research, 50(4), 525-544.

Maddux, C. (1984) Educational microcomputing: The need for research. Computers in the Schools, 1(1), 35-41.

McDougall, A. (1975) The computer as part of the educational environment: A review of the research. Australian Journal of Education, 19(2), 178-190.

Ryba, K. & Chapman, J. (1983) Toward improving learning strategies an personal adjustment with computers. The Computing Teacher, 11(1), 48-53.

Suppes, P. & Morningstar, M. (1969) Computer-assisted instruction. Science, October, 166, 343-350.

Thomas, D. (1979) The effectiveness of computer-assisted instruction in secondary schools. Association for Educational Data Systems Journal, 12, 103-116.

Tinker, R. (1983) New dimensions in science and mathematics software. Classroom Computer News, 3(4), 36-39.

Vinsonhaler, J. & Bass, R. (1972) A summary of ten major studies on CAI drill and practice. Educational Technology, July, 12, 29-32.

BEST COPY

Willett, J.; Yamashita, J.; & Anderson, R. (1983) A meta-analysis of instructional systems applied in science teaching. Journal of Research in Science Teaching, 20(5), 405-417.

Willis, J. (1984) Educational computing: Current status and future directions. Computers in the Schools, 1(1), 3-12.

Wise, K. & Okey, J. (1983) The impact of microcomputer based instruction on student achievment. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, April, Dallas, Texas.

BEST COPY

Table 1

Findings from a Chronology of Computer-Based Education Reviews

Reviewers	Date	Grade Level and Subject	Analysis Technique	Number of Studies	Conclusions or Effects
Vinsonhaler & Bass	1972	Grades 1-6 math and language arts	Narrative and grade equivalents	34	$\overline{geu}_{lang.\ arts} = .3$ $\overline{geu}_{math} = .4$
Edwards, Norton, Taylor, Van Dusseldorp, & Weiss	1974	All grade levels all subjects	Narrative	33	(see text narrative)
Thomas	1979	All grade levels all subjects	Narrative	> 50	(see text narrative)
Kulik, Kulik, & Cohen	1980	College level all subjects	Meta analysis	59	$\overline{\Delta} = .25$
Burns & Bozeman	1981	Elementary and secondary mathematics	Meta analysis	40	$\overline{\Delta}_{dp} = .34$ $\overline{\Delta}_{tutorial} = .44$
Willett, Yamashita, & Anderson	1983	Elementary and secondary science	Meta analysis	14*	$\overline{\Delta}_{CAI} = .01$ $\overline{\Delta}_{CMI} = .05$ $\Delta_{lab} = 1.45$
Wise & Okey	1983	Elementary and secondary math and science	Meta analysis	12	$\overline{\Delta} = .82$
Kulik, Bangert, & Williams	1983	Secondary all subjects	Meta analysis	51	$\overline{\Delta} = .32$
Kulik, Kulik, & Bangert-Drowns	1985	Grades 1-6 all subjects	Meta analysis	32	$\overline{\Delta}_{CAI} = .47$ $\overline{\Delta}_{CMI} = .07$

*In this review more than one outcome is reported for a study.